The Measure of Beauty Created in Nature:
The Golden Ratio

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Allah has appointed a measure for all things. (Surat at-Talaq, 3)

… You will not find any flaw in the creation of the All-Merciful. Look again-do you see any gaps? Then look again and again. Your sight will return to you dazzled and exhausted! (Surat al-Mulk, 3-4)

... If a pleasing or exceedingly balanced form is achieved in terms of elements of application or function, then we may look for a function of the Golden Number there ... The Golden Number is a product not of mathematical imagination, but of a natural principle related to the laws of equilibrium. (1)

What do the pyramids in Egypt, Leonardo do Vinci's portrait of the Mona Lisa, sunflowers, the snail, the pine cone and your fingers all have in common?

The answer to this question lies hidden in a sequence of numbers discovered by the Italian mathematician Fibonacci. The characteristic of these numbers, known as the Fibonacci numbers, is that each one consists of the sum of the two numbers before it. (2)

Fibonacci numbers

L. Pisano Fibonacci

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, 2584, …

Fibonacci numbers have an interesting property. When you divide one number in the sequence by the number before it, you obtain numbers very close to one another. In fact, this number is fixed after the 13th in the series. This number is known as the "golden ratio."

GOLDEN RATIO = 1.618

233 / 144 = 1.618

377 / 233 = 1.618

610 / 377 = 1.618

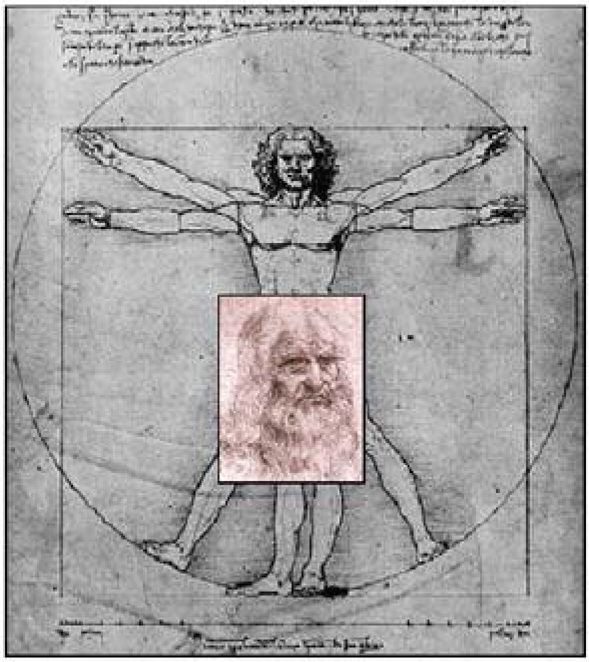
987 / 610 = 1.618

1597 / 987 = 1.618

2584 / 1597 = 1.618

THE HUMAN BODY AND THE GOLDEN RATIO

When conducting their researches or setting out their products, artists, scientists and designers take the human body, the proportions of which are set out according to the golden ratio, as their measure. Leonardo da Vinci and Le Corbusier took the human body, proportioned according to the golden ratio, as their measure when producing their designs. The human body, proportioned according to the golden ratio, is taken as the basis also in the Neufert, one of the most important reference books of modern-day architects.

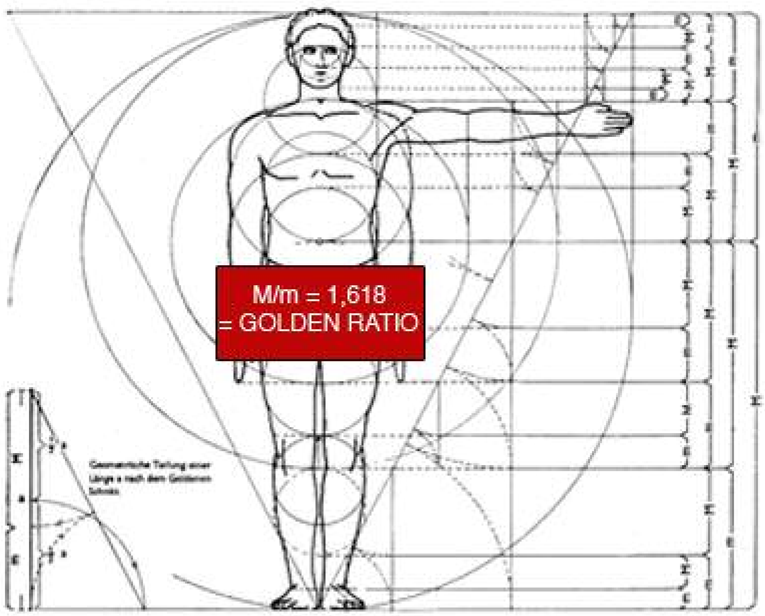


Leonardo da Vinci used the golden ratio in setting out the proportions of the human body.

THE GOLDEN RATIO IN THE HUMAN BODY

The "ideal" proportional relations that are suggested as existing among various parts of the average human body and that approximately meet the golden ratio values can be set out in a general plan as follows: (3)

The M/m level in the table below is always equivalent to the golden ratio. M/m = 1.618



The first example of the golden ratio in the average human body is that when the distance between the navel and the foot is taken as 1 unit, the height of a human being is equivalent to 1.618. Some other golden proportions in the average human body are:

The distance between the finger tip and the elbow / distance between the wrist and the elbow,
The distance between the shoulder line and the top of the head / head length,
The distance between the navel and the top of the head / the distance between the shoulder line and the top of the head,
The distance between the navel and knee / distance between the knee and the end of the foot.

The Human Hand

Lift your hand from the computer mouse and look at the shape of your index finger. You will in all likelihood witness a golden proportion there.

Our fingers have three sections. The proportion of the first two to the full length of the finger gives the golden ratio (with the exception of the thumbs). You can also see that the proportion of the middle finger to the little finger is also a golden ratio. (4)

You have **two** hands, and the fingers on them consist of **three** sections. There are **five** fingers on each hand, and only **eight** of these are articulated according to the golden number: 2, 3, 5, and 8 fit the Fibonacci numbers.

The Golden Ratio in the Human Face

There are several golden ratios in the human face. Do not pick up a ruler and try to measure people's faces, however, because this refers to the "ideal human face" determined by scientists and artists.

For example, the total width of the two front teeth in the upper jaw over their height gives a golden ratio. The width of the first tooth from the centre to the second tooth also yields a golden ratio. These are the ideal proportions that a dentist may consider. Some other golden ratios in the human face are:

Length of face / width of face,
Distance between the lips and where the eyebrows meet / length of nose,
Length of face / distance between tip of jaw and where the eyebrows meet,
Length of mouth / width of nose,
Width of nose / distance between nostrils,
Distance between pupils / distance between eyebrows.

Golden Proportion in the Lungs

In a study carried out between 1985 and 1987 (5), the American physicist B. J. West and Dr. A. L. Goldberger revealed the existence of the golden ratio in the structure of the lung. One feature of the **network of the bronchi** that constitutes the lung is that it is asymmetric. For example, the windpipe divides into two main bronchi, one long (the left) and the other short (the right). This asymmetrical division continues into the subsequent subdivisions of the bronchi. (6) It was determined that in all these divisions the proportion of the short bronchus to the long was always 1/1.618.

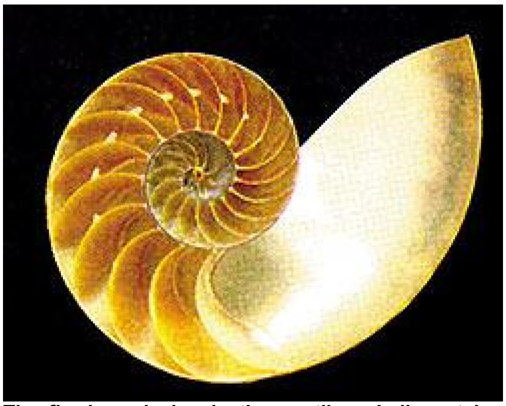
THE GOLDEN RECTANGLE AND THE DESIGN IN THE SPIRAL

A rectangle the proportion of whose sides is equal to the golden ratio is known as a "golden rectangle." A rectangle whose sides are 1.618 and 1 units long is a golden rectangle. Let us assume a square drawn along the length of the short side of this rectangle and draw a quarter circle between two corners of the square. Then, let us draw a square and a quarter circle on the remaining side and do this for all the remaining rectangles in the main rectangle. When you do this you will end up with a spiral.

The British aesthetician William Charlton explains the way that people find the spiral pleasing and have been using it for thousands of years stating that we find spirals pleasing because we are easily able to visually follow them. (7)

The spirals based on the golden ratio contain the most incomparable designs you can find in nature. The first examples we can give of this are the spiral sequences on the sunflower and the pine cone. In addition to this, an example of Almighty Allah's flawless creation and how He has created everything with a measure, the growth process of many living things also takes place in a logarithmic spiral form. The curves in the spiral are always the same and the main form never changes no matter their size. No other shape in mathematics possesses this property. (8)

The Design in Sea Shells



The flawless design in the nautilus shell contains the golden ratio.

When investigating the shells of the living things classified as mollusks, which live at the bottom of the sea, the form and the structure of the internal and external surfaces of the shells attracted the scientists' attention:

The internal surface is smooth, the outside one is fluted. The mollusk body is inside shell and the internal surface of shells should be smooth. The outside edges of the shell augment a rigidity of shells and, thus, increase its strength. The shell forms astonish by their perfection and profitability of means spent on its creation. The spiral's idea in shells is expressed in the perfect geometrical form, in surprising beautiful, "sharpened" design. (9)

The shells of most mollusks grow in a logarithmic spiral manner. There can be no doubt, of course, that these animals are unaware of even the simplest mathematical calculation, let alone logarithmic spirals. So how is it that the creatures in question can know that this is the best way for them to grow? How do these animals, that some scientists describe as "primitive," know that this is the ideal form for them? It is impossible for growth of this kind to take place in the absence of a consciousness or intellect. That consciousness exists neither in mollusks nor, despite what some scientists would claim, in nature itself. It is totally irrational to seek to account for such a thing in terms of chance. This design can only be the product of a superior intellect and knowledge, and belongs to Almighty Allah, the Creator of all things:

"My Lord encompasses all things in His knowledge so will you not pay heed?" (Surat al-An'am, 80)

Growth of this kind was described as "gnomic growth" by the biologist Sir D'Arcy Thompson, an expert on the subject, who stated that it was impossible to imagine a simpler system, during the growth of a seashell, than which was based on widening and extension in line with identical and unchanging proportions. As he pointed out, the shell constantly grows, but its shape remains the same. (10)

One can see one of the best examples of this type of growth in a nautilus, just a few centimetres in diameter. C. Morrison describes this growth process, which is exceptionally difficult to plan even with human intelligence, stating that along the nautilus shell, an internal spiral extends consisting of a number of chambers with mother-of-pearl lined walls. As the animal grows, it builds another chamber at the spiral shell mouth larger than the one before it, and moves forward into this larger area by closing the door behind it with a layer of mother-of-pearl. (11)

The scientific names of some other marine creatures with logarithmic spirals containing the different growth ratios in their shells are:

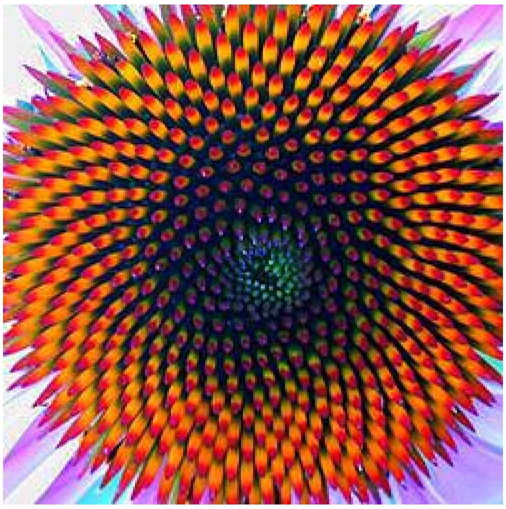
Haliotis Parvus, Dolium Perdix, Murex, Fusus Antiquus, Scalari Pretiosa, Solarium Trochleare.

Ammonites, extinct sea animals that are today found only in fossil form, too, had shells developing in logarithmic spiral form.

Growth in a spiral form in the animal world is not restricted to the shells of mollusks. Animals such as antelopes, goats and rams complete their horn development in spiral forms based on the golden ratio. (12)

The Golden Ratio in the Hearing and Balance Organ

The cochlea in the human inner ear serves to transmit sound vibrations. This bony structure, filled with fluid, has a logarithmic spiral shape with a fixed angle of ?=73°43´ containing the golden ratio.



Horns and Teeth That Grow in a Spiral Form

Examples of curves based on the logarithmic spiral can be seen in the tusks of elephants and the now-extinct mammoth, lions' claws and parrots' beaks. The eperia spider always weaves its webs in a logarithmic spiral. Among the micro-organisms known as plankton, the bodies of globigerinae, planorbis, vortex, terebra, turitellae and trochida are all constructed on spirals.

THE GOLDEN RATIO IN THE MICRO WORLD

Geometrical shapes are by no means limited to triangles, squares, pentagons or hexagons. These shapes can also come together in various ways and produce new three-dimensional geometrical shapes. The cube and the pyramid are the first examples that can be cited. In addition to these, however, there are also such three-dimensional shapes as the tetrahedron (with regular four faces), octahedron, dodecahedron and icosahedron, that we may never encounter in our daily lives and whose names we may never even have heard of. The dodecahedron consists of 12 pentagonal faces, and the icosahedron of 20 triangles. Scientists have discovered that these shapes can all mathematically turn into one another, and that this transformation takes place with ratios linked to the golden ratio.

Three-dimensional forms that contain the golden ratio are very widespread in micro-organisms. Many viruses have an icosahedron shape. The best known of these is the Adeno virus. The protein sheath of the Adeno virus consists of 252 protein subunits, all regularly set out. The 12 subunits in the corners of the icosahedron are in the shape of pentagonal prisms. Rod-like structures protrude from these corners.

The first people to discover that viruses came in shapes containing the golden ratio were Aaron Klug and Donald Caspar from Birkbeck College in London in the 1950s. The first virus they established this in was the polio virus. The Rhino 14 virus has the same shape as the polio virus.

Why is it that viruses have shapes based on the golden ratio, shapes that it is hard for us even to visualise in our minds? A. Klug, who discovered these shapes, explains:

My colleague Donald Caspar and I showed that the design of these viruses could be explained in terms of a generalization of icosahedral symmetry that allows identical units to be related to each other in a quasi-equivalent way with a small measure of internal flexibility. We enumerated all the possible designs, which have similarities to the geodesic domes designed by the architect R. Buckminster Fuller. However, whereas Fuller's domes have to be assembled following a fairly elaborate code, the design of the virus shell allows it to build itself. (14)

Klug's description once again reveals a manifest truth. There is a sensitive planning and intelligent design even in viruses, regarded by scientists as "one of the simplest and smallest living things." (15) This design is a great deal more successful than and superior to those of Buckminster Fuller, one of the world's most eminent architects.

The dodecahedron and icosahedron also appear in the silica skeletons of radiolarians, single-celled marine organisms.

Structures based on these two geometric shapes, like the regular dodecahedron with feet-like structures protruding from each corner, and the various formations on their surfaces make up the varying beautiful bodies of the radiolarians. (16)

As an example of these organisms, less than a millimetre in size, we may cite the icosahedron based *Circigonia Icosahedra* and the *Circorhegma Dodecahedra* with dodecahedron skeleton. (17)

The Golden Ratio in DNA

The molecule in which all the physical features of living things are stored, too, has been created in a form based on the golden ratio. The DNA molecule, the very program of life, is based on the golden ratio. DNA consists of two intertwined perpendicular helixes. The length of the curve in each of these helixes is 34 angstroms and the width 21 angstroms. (1 angstrom is one hundred millionth of a centimetre.) 21 and 34 are two consecutive Fibonacci numbers.

THE GOLDEN RATİO İN SNOW CRYSTALS

The golden ratio also manifests itself in crystal structures. Most of these are in structures too minute to be seen with the naked eye. Yet you can see the golden ratio in snow flakes. The various long and short variations and protrusions that comprise the snow flake all yield the golden ratio. (18)

THE GOLDEN RATIO IN SPACE

In the universe there are many spiral galaxies containing the golden ratio in their structures.

The Golden Ratio in Physics

You encounter Fibonacci series and the golden ratio in fields that fall under the sphere of physics. When a light is held over two contiguous layers of glass, one part of that light passes through, one part is absorbed, and the rest is reflected. What happens is a "multiple reflection." The number of paths taken by the ray inside the glass before it emerges again depends on the number of reflections it is subjected to. In conclusion, when we determine the number of rays that re-emerge, we find that they are compatible with the Fibonacci numbers.

The fact that a great many unconnected animate or inanimate structures in nature are shaped according to a specific mathematical formula is one of the clearest proofs that these have been specially designed. The golden ratio is an aesthetic rule well known and applied by artists. Works of art based on that ratio represent aesthetic perfection. Plants, galaxies, micro-organisms, crystals and living things designed according to this rule imitated by artists are all examples of Allah's superior artistry. Allah reveals in the Qur'an that He has created all things with a measure. Some of these verses read:

… Allah has appointed a measure for all things. (Surat at-Talaq, 3)

… Everything has its measure with Him. (Surat ar-Ra'd, 8)

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